RECONSTRUCTION OF PAST CLIMATIC VARIABILITY

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13. ABSTRACT

New ring-width chronologies are obtained for the purpose of extending the existing climate data base back in time and to a wider geographic area. A total of 139 new sites have been collected and progress on analysis is reported. Compilation of long climatic data is proceeding and multivariate models give increased predictability of climate from tree rings. Expansion of the data base to new areas in North America and Europe is being planned.

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Summary (Non-technical)

Dendroclimatology, the use of tree rings to reconstruct variations in past climate, is the only discipline that is presently capable of providing quantitative information on the yearly and decadal variations in prehistoric climate. Well dated and replicated proxy series of climate are obtained from corings made from 10 to 30 trees in a given site. Beams from archaeological ruins or remains of old trees on the ground may be cross-dated with living trees to extend the proxy series back in time.

The best proxy series may be selected to provide a grid of tree-ring sites equivalent to a grid of climatic stations and the spatial variation in tree growth can be calibrated with the spatial variation in climate. Transfer functions can be obtained by this procedure which may be applied to the growth amounts during years prior to historical records to calculate and reconstruct the past climate. A grid of 49 tree-ring stations over western North America gives us predictability of past climate for large areas over North America and the North Pacific.

The object of the ARPA project is to extend this tree-ring data base over a wider geographic area, to new species and further back in time. This extension will allow better and longer climatic reconstruction and broaden the area to eastern North America and the North Atlantic. Ultimately, we hope to obtain more materials from other continents and will add these data to reconstruct climatic anomalies for the entire northern hemisphere.

The major accomplishments of the first six months have been the collection, dating, processing and cataloging of replicated tree-ring materials from more than 139 sites in North America and Europe. A total of 101 of these sites were sampled or acquired in whole or in part by means of ARPA project funds (see tables 1, 2, 3, 4 and fig. 1). Initial examination has been accomplished for well over half of the sites and 19 of these have already been completed through

the data processing stage. Selection of stations to be used for dendroclimatic purposes has not yet been made. Because of equipment failure, $3,470 was invested in new electronic equipment. This has allowed us to keep pace with the heavy load on the tree-ring measuring machines resulting from ARPA project aquisitions.

The support from ARPA has significantly broadened the range of species and sampling localities for Mexico, northeastern, midwestern and southwestern United States (see Fig. 1 and Tasks 1, 2 and 3). This broadened data base is expected to lengthen and strengthen the climatic information and allow estimation of past climate in a wider geographic area than has been possible up to now.

Climatic data are presently being screened and compiled for subsequent ring-width calibration (see Task 4). Since the work began in July, we have refined our calibration model and have been able to almost triple the predictability of past climatic anomalies using already existing ring-width series for western North America (see Introduction). The new model will eventually be applied to the wider collections obtained in this project when materials are completely worked and the data suitably processed.

Initial contacts are being made with collaborators in Europe--a major step toward broadening our data base to a world-wide scope.

Paleoclimatic reconstruction made from tree rings are expected to assist those projects aimed at modeling the circulation of the earth's atmosphere in order to predict future climates. The long record in tree rings provides a better estimate of climatic variability because it incorporates long-term variations not present in the short historical records of climate.

INTRODUCTION

The premise underlying the project work is that information derived from rings of trees distributed over a wide geographic area, such as a continent, can be used to reconstruct climate for a still wider area including the oceans bordering the continents. Yearly anomalies in circulation of the atmosphere as measured by the variance in surface pressure over the North Pacific and western North America have already been successfully reconstructed by using 49 ring-width chronologies from western North America. In work published by Fritts et. al. (1972) the variance in tree rings explained approximately 20% of the pressure variance for winter and 20% for summer for large portions of the Northern Hemisphere. Refinements of techniques used earlier (work done in conjunction with NSF grant GA-26581) have improved the results and now we are able to use the variance in tree rings to explain approximately 55% of the variance in pressure for both the summer and winter seasons.

This improvement makes us confident that continued efforts to widen and extend the tree-ring data base over North America and to eventually include other continents of the world, will make possible global-scale reconstruction of climatic anomalies for periods prior to historical records. The ARPA supported work has enabled us to substantially increase the rate by which we are extending this data base. Three field parties (Tasks 1, 2 and 3) collected this past summer season in Chihuahua, Coahuila, and Baja California, Mexico; in northern Arizona, northern New Mexico, southern Colorado, and southern Utah; and in New England and northern Minnesota. Also, an older collection was obtained from Professor Robert Bell of the University of Oklahoma. This collection was originally housed at the University of Chicago and includes old timbers, cores, and cross-sections from trees sampled in the 1930's and 1940's in eastern United States. Additional materials that were collected and made available to the ARPA projects include:

(1) 5 sites collected in Sweden by T. P. Harlan during the summer of 1972 while on his personal travels; (2) 1 site collected from the San Gorgonio Mountains in California by Robert Tosh; (3) 12 sites collected by J. S. Dean and party in work funded by the National Park Service, U. S. Forest Service, the Museum of Northern Arizona, and the Laboratory of Tree-Ring Research; (4) 12 sites collected for the Lake Powell Project by C. W. Stockton; and (5) 7 sites collected by C. W. Ferguson for Yellowstone National Park.

All materials available for the ARPA work are listed in Tables 1, 2, 3 and 4. It must be pointed out that only a small set of these sites will in final analysis prove suitable for dendroclimatic work. In some areas too few usable specimens (less than 10 trees per site) will be available for chronology development. The ring sequences in some trees will be found upon examination to be undatable or the trees too young to extend the climatic information beyond the existing record. Others may possess a climatic signal that is too weak or may be severely affected by site factors which obscure the climatic information the rings contain. In the case of the University of Chicago collection, which was assembled 30 to 40 years ago, each site must be re-sampled to bring the ring-width chronology up to date.

The initial task of the ARPA project is to sift through this diverse set of tree-ring data, to date the materials and to select the best of them for subsequent measurement and processing so that they may be utilized in future ARPA work. With the present level of funding a portion of these collections can be completely processed by the end of the first year. With the exception of materials from the University of Chicago collection, processing of the most valuable 1972 collections should be completed at least by the end of the second year.

The development of the climatic data bank (Task 4) is progressing well and plans are being developed for consultation with H. H. Lamb at his laboratory

in Norwich, England. In conjunction with this consultation, contacts are planned with a number of tree-ring workers in Europe to propose cooperative work. Funds are also being solicited elsewhere to conduct an international workshop in 1974 to facilitate the organization of this international project.

The following are reports from the individuals directing each of the above mentioned tasks. Following the reports are tables listing the sites collected and progress thus far. Fig. 1 at the end of this report shows the location of all mentioned sites occurring within Mexico and the United States.

Task 1 reported by M. A. Stokes

Field work this past summer represented an attempt to extend the tree-ring data base over a wider area in Mexico. It was hoped that this sampling would begin to produce a grid of tree-ring chronologies similar in extent and quality to those for the United States.

The field party made collections along an arc running from the Big Bend area through Saltillo, Coahuila and up the mountains west of Chihuahua City. In addition collections were made near Creel, Chihuahua, in the heart of the Sierra Madre Occidental. One promising area in Coahuila was not sampled due to adverse weather and road conditions. Results of field work in northern Mexico and progress on working up the collections are included in Table 1.

Two of the above chronologies appear usable for climatic reconstruction. Three other sites may prove to be satisfactory, but at the present time specimens are still under examination. A number of factors are being encountered which make Mexican dendrochronology difficult. Many Mexican forests have been heavily cut or severely disturbed so that there are few very old trees with a suitable climatic record. A rapid growth rate under warm, moist conditions results in a short life span among Mexican trees, hence short ring-width series. Also, some Mexican tree species have ring series in which the cross-dating is problematical.

The same field party sampled at the southern tip of Baja California. A pack trip was made to the summit of the Sierra de la Laguna range where collections were obtained from pinyon pine (Pinus cembroides). To date, analysis has revealed problems in the differentiation of true annual rings from false rings. This may be the result of adaptation to a tropical climatic regime or anomalous growth, characteristic of this species of pinyon pine. Continuing examination may eventually resolve these difficulties and provide a useful series.

A further collection is to be made during the spring of 1973 in the Sierra del San Pedro Martir in northern Baja California. There is considerably more likelihood that old and usable trees will be found there.

Field and laboratory study has indicated that Pseudotsuga menziesii (Douglas fir) and Pinus strobiformis (Mexican white pine) are the best species available for dating purposes in Mexico, although other species such as Pinus ponderosa, Pinus cembroides (pinyon pine), Pinus leiophylla var. Chihuahuana (Chihuahua pine) and Picea chihuahuana (Chihuahua spruce) can be dated. Because ponderosa pine grows at lower elevations and on drier sites, more problems are encountered with it than with species from high elevations.

Limber pine cores (Pinus flexilis) collected from the San Gorgonio Mountains in southern California by Robert Tosh of Mentone, California, have been made available to this project. This material is composed of 238 cores from 101 trees. The dating and measuring have shown the chronology developed from this collection to extend from 18 B.C. to A.D. 1971. A number of these cores are being selected to be processed for the ARPA work.

Five sites of Scotch pine (Pinus sylvestris) in central and northern Sweden were sampled by Thomas P. Harlan of the Laboratory in June of 1972. The samples have been examined and dated and have also been made available to the ARPA project. After measurements are made, data processing will be done on ARPA funds.

Task 2 reported by J. S. Dean

The principal objective of Task 2 is the construction of a geographical network of tree-ring chronology stations throughout the plateau area of the Southwest in order to assess tree-growth-climate relationships and to isolate spatial and temporal patterns of variation in past climatic conditions in the region. The network of modern stations corresponds to an already existing grid of tree-ring chronologies based on samples from archaeological sites. Dendroclimatic analyses of the modern tree-ring series will be used to calibrate the archaeological sequences with local climatic conditions as a basis for more accurate reconstructions of past climatic variability in the Southwest. Those modern series that extend far enough back into the past will be merged with their archaeological counterparts to produce long-range chronologies suitable for detailed studies of past climatic conditions in the Southwest from A.D. 700 to the present.

Thirty-one modern tree-growth site collections are currently available for study (Table 2). Twelve of these sites were wholly or partially sampled during the past few years under the sponsorship of the Laboratory of Tree-Ring Research, the National Park Service, the U. S. Forest Service, and the Museum of Northern Arizona. Availability of this material for use in the Task 2 program eliminated the necessity for collecting some stations, while other site collections had only to be augmented with a few additional samples. Nineteen sites in Arizona, Utah, Colorado, and New Mexico were newly sampled and five site collections were augmented under ARPA sponsorship in 1972 (Table 2). Wherever possible, multi-species site collections were made as a basis for analyses designed to isolate inter-species differences in climatic response to be used in reconstructing seasonal variability in past climates. A total of 799 cores from 398 trees representing 24 sites have thus far been

collected as part of Task 2. Twelve to fifteen additional sites in New Mexico will be sampled in the near future to complete the geographical coverage of the network.

Laboratory analyses of the collections is proceeding rapidly (Table 2). Specimen study has been completed for 14 sites and computer processing has begun on the material from six of these collections. So far, four individual species chronologies from three sites have been computerized, six other chronologies are in advanced stages of development, and 12 additional dated species sets are nearly ready for computer processing. Twenty-two species sample sets have not yet been studied; however, cursory examination of some of them indicates that they possess a high degree of dendroclimatic potential.

Task 3 reported by M. A. Wiseman

The objective of Task 3 is to broaden the coverage of tree-ring data into northeastern, southeastern and midwestern North America. Two different collections have been obtained and are in the process of examination.

Over 300 cores were collected from sites in the New England states and in northern Minnesota by H. C. Fritts during August, 1972. All cores have been prepared for analysis, and the New England sites have been fully examined (Table 3). Two New England red spruce sites (Picea rubens) show good dating, length and replication and will be useful for paleoclimatic analysis. The red pine sites (Pinus resinosa) from northern Minnesota are presently being examined and dated.

The second collection acquired through ARPA funding consists of over 2000 cross-sections and cores from southeastern and midwestern states taken in 1937-1942 by the University of Chicago. In addition, the collection has approximately 1000 specimens from historical and archaeological sites in the same regions, which may be of value in extending chronologies back in time after the modern specimens have been worked and cross dating has been established.

Progress in analyzing the University of Chicago material has been slow, as the collection was received in a state of disorganization. It has now been entirely re-sorted and examination is proceeding at a satisfactory pace (Table 3).

Dating was reported for some of the specimens (Hawley, 1941), but some controversy exists concerning validity of the dates. From notes accompanying the collection, two initial sites indicating good cross-dating have been selected: Jefferson County, Missouri, and Norris Basin, Tennessee (Table 3). Specimens have been prepared and are being examined independently of former dating efforts. The erratic growth nature of eastern red cedar (Juniperus virginiana) has made analysis difficult, however, cross-dating has been found. The greater-than-400-year length of these chronologies should be useful for climatic analyses. A preliminary analysis of variance is planned as a test case for cedar to determine the climatic value of the species.

In the Chicago collection, an estimated 38 sites delimited by county boundaries and distributed in at least 9 states indicates enough replicated sampling to be of potential value as climatologic chronologies if cross-dating is established (Figure 1). In order to locate the sites where modern re-sampling will be most profitable, a spot check for cross-dating in each site is planned before further in-depth analysis proceeds.

Over 65 sites in the collection have too few specimens to be used as climatic chronologies, but these perhaps may be utilized to substantiate adjacent sites or to provide leads on areas for further collection.

Additional climatic information may also be gained from the array of species represented but not yet analyzed: cypress (Taxodium distichum), northern white cedar (Thuja occidentalis), tamarack (Larix laricina), hemlock (Tsuga canadensis), white oak (Quercus alba), and shortleaf pine (Pinus echinata).

Task 4 reported by C. W. Stockton

Establishment of a tree ring - climatic data bank has progressed at a satisfactory rate. The climatic data collection work, being a conjunctive effort with the Center for Climatic Research at the University of Wisconsin, has been partitioned on an east-west North American continent basis--the University of Wisconsin group concentrating on the area east of the 100th meridian, our group (University of Arizona) west of the 100th meridian. The effort has utilized funds from GA-26581, NSF, as well as from ARPA. At the present, we have screened the station records for those stations with precipitation and temperature records of at least 70 years duration and a fairly stable location. The result has been 162 stations, including both first and second order, for which data have been collected and punched on computer cards. About 60% of these stations have resulted from the ARPA supported work. We are now in the process of estimating infrequently occurring missing monthly values using the technique outlined by McDonald (1957). In addition we are checking (and correcting where necessary) each of these records for homogeneity by using a double mass analysis technique for the total monthly precipitation records and a modified accumulated first difference method for average monthly temperature records.

We will use these data for testing purposes and to extend regional averages in the Decennial Census for the United States backwards beyond 1930. Working with the group from the University of Wisconsin, we are establishing a technique and the necessary computer software to weight each record so that stability in the regional mean will be assured as the sample size diminishes with progression back in time.

Ultimately, we hope to have a grid of regional temperature and precipitation averages for the North American continent that can be used to climatically cali-

brate our developing North American continent tree-ring network.

Associated Field Sampling

A subcontract, which is simultaneously being conducted for the Lake Powell Project, a NSF, RANN funded effort, has resulted in 9 new chronologies and the up-dating of 2 existing tree-ring chronologies which can be utilized in the ARPA investigation. An additional set of sites was collected by C. W. Ferguson on a project sponsored by Yellowstone National Park. A summary of these collections is shown in Table 4.

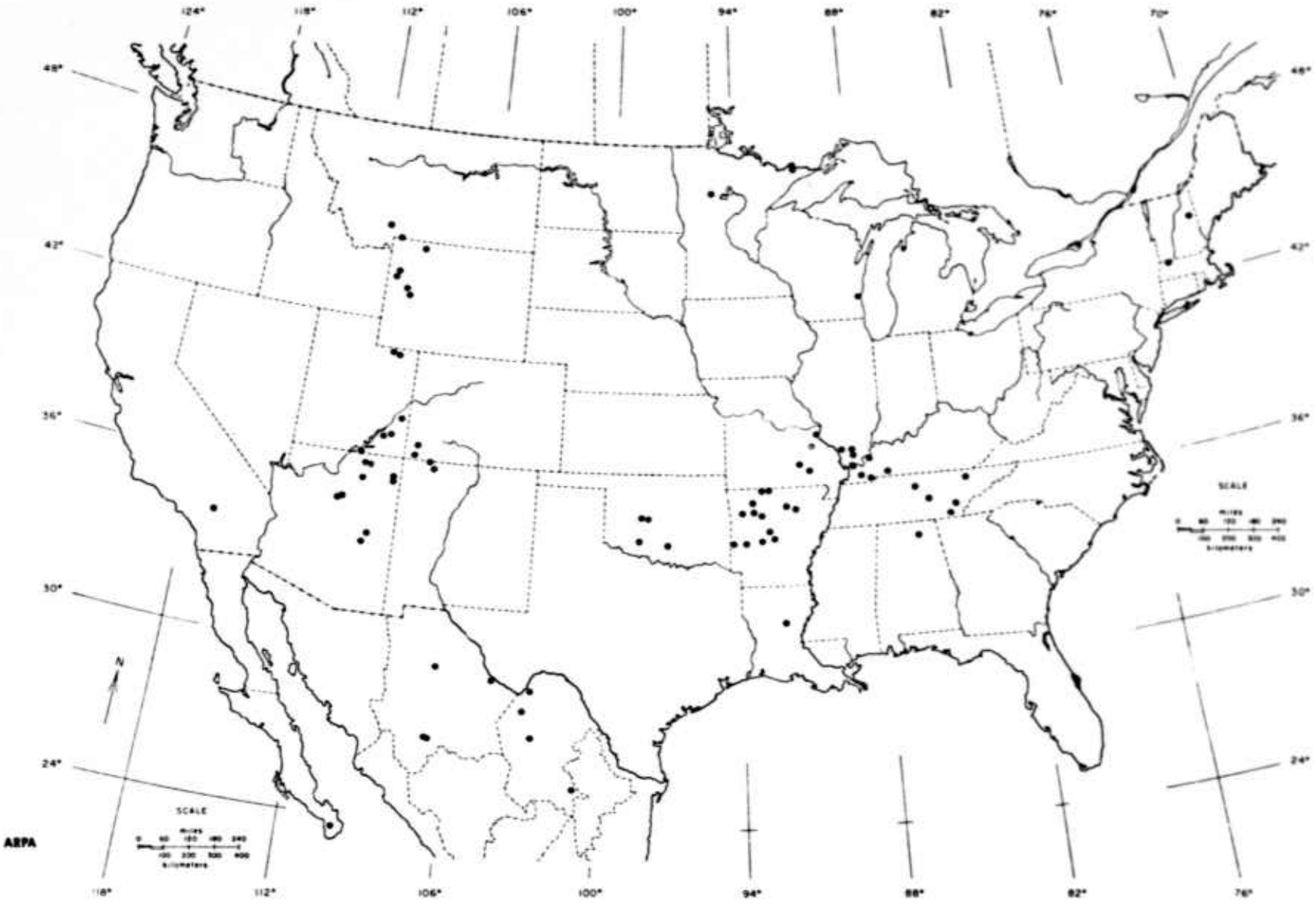

Figure 1.-- Spatial array of collection localities for ARPA Tasks 1, 2, 3 and 4. Each dot represents from 1 to 3 sites or one county. See text for explanation.

Table 1.--Progress of Task 1. Collections in Mexico, Southern California and Sweden

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	DATING CHECKED	CHRON. LENGTH	MEASURED	DATA PROCESSED	SELECTED CORES/TREES
ARPA	Sierra del Carmen/ Madera Canyon A, Coahuila	DF	26/14	X	X	1642-1971	X	X	
"	Sierra del Carmen/ Madera Canyon B, Coahuila	MWP	14/6	X	X	1676-1971	X	X	
"	Sierra del Carmen/ Madera Canyon C, Coahuila	PP	13/7	X	X	1782-1971	X	X	
"	Sierra del Carmen/ Cojos Canyon Coahuila	PNN	18/10	X	X	1826-1971	X		
"	Sierra Rica Chihuahua	PNN	33/18	X					
"	Santa Fe del Pino, Coahuila	PP	57/28	X		1815-1972			
"	Sierra de Madera A, Coahuila	DF	4/2	X		1603-1972			
"	Sierra de Madera B, Coahuila	MWP	10/5	X					
"	Sierra de Madera C, Coahuila	PP	42/21	X					
"	Saltillo, Coahuila	PP	51/26	X		1892-1972			
"	Sierra del Nido A1, Chihuahua	PNN	30/15	X					
"	Sierra del Nido A2, Chihuahua	CP	20/11	X					

DF-Douglas fir; MWP-Mexican white pine; PP-Ponderosa pine; PNN-Mexican pinyon pine; CP-Chihuahua pine; SCP-Scotch pine; CS-Chihuahua spruce; LBP-Limber pine.

Table 1.-- continued.

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	DATING CHECKED	CHRON. LENGTH	MEASURED	DATA PROCESSED	SELECTED CORES/TREES
ARPA	Sierra del Nido B1, Chihuahua	DF	11/6	X	X	1568-1972	X	X	
"	Sierra del Nido B2, Chihuahua	MWP	7/4	X	X	1621-1972	X	X	
"	Sierra Madre, Creel Airport, Chihuahua	DF	21/11	X	X	1642-1972			
"	Sierra Madre, Rio Oteros, Chihuahua	CS	21/10	X	X	1753-1972	X	X	
"	Sierra de la Laguna Baja California del Sur	PNN	43/23	X					
R. Tosh	San Gorgonio Mtns. S. California	LBP	238/101	X	X	18 B.C.-1971			
Harlan	Muddas National Park, Sweden	SCP	7/5	X	X	1646-1971			
"	Muddas National Park, Site A, Sweden	SCP	13/11	X	X	1571-1971			
"	Östersund, Sweden	SCP	30/14	X	X	1670-1971			
"	Grimnases, Sweden	SCP	2/1	X	X	1848-1971			
"	Arosjak, Sweden	SCP	8/7	X	X	1613-1971			

DF-Douglas fir; MWP-Mexican white pine; PP-Ponderosa pine; PNN-Mexican pinyon pine; CP-Chihuahua pine; SCP-Scotch pine; CS-Chihuahua spruce; LBP-Limber pine.

Table 2.--Progress of Task 2. Collections in the Southwest Plateau Area

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	DATING CHECKED	CHRON. LENGTH	MEASURED	DATA PROCESSED	SELECTED CORES/TREES
ARPA	Grasshopper, Ariz.	PP	36/18	X	X	1641-1972	X	X	
"	Salt River Draw, AZ.	PP	21/10	X	X	1675-1972	X	X	
"	Oak Creek, Ariz.	PNN	30/15	X	X	1694-1972	X	X	
NPS* ARPA	Spider Rock, Ariz.	PNN	46/23						
NPS ARPA	Spider Rock, Ariz.	DF	32/16	X	X	1627-1972			
NPS ARPA	Canyon de Chelly, Arizona	DF	20/7	X	X	1388-1972			
ARPA	Tseh Ya Kin Canyon, Arizona	DF	24/12						
NPS ARPA	Tsegi Point, Ariz.	PNN	40/20						
NPS	Tsegi Point, Ariz.	DF	14/7	X	X	1532-1971			
ARPA NPS, TRL*	Betatakin Canyon, AZ.	DF	77/24	X	X	1382-1972			
NPS ARPA	Kinbiko Rim, Ariz.	JUN	22/11	X		1672-1972			
NPS	Kinbiko Rim, Ariz.	PNN	18/9						
TRL	Kiet Siel Canyon, Arizona	DF	48/12						
NPS	Northern Black Mesa, Arizona	DF	12/6	X	X	1551-1968	X		

PP-Ponderosa pine; PNN- Colorado pinyon pine; DF-Douglas fir; JUN-Juniper

*NPS-National Park Service; TRL-Tree-Ring Laboratory

Table 2.--continued.

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	DATING CHECKED	CHRON. LENGTH	MEASURED	DATA PROCESSED	SELECTED CORES/TREES
NPS	Northern Black Mesa, Arizona	PP	16/8	X	X	1569-1968	X		
NPS	Northern Black Mesa, Arizona	PNN	8/4	X	X	1600-1968	X	X	8/4
TRL	Dinnebito, Arizona	PNN	44/20						
ARPA	Shonto Plateau, AZ.	PNN	30/15						
ARPA	Show Low, Arizona	PP	30/15						
"	Jack's Canyon, Ariz.	PNN	30/15						
"	Robinson Mt., Ariz.	PP	30/15						
"	Medicine Valley, AZ.	PP	30/15						
"	White Horse Hills, Arizona	PP	30/15						
"	Hunting Station, AZ.	PNN	30/15						
"	Slate Mt., Ariz.	PP	24/12						
"	Navajo Mt., Utah	PP	30/15						
"	Navajo Mt., Utah	PNN	26/13						
"	Kane Spring, Utah	PNN	30/15						
"	White Canyon, Utah	DF	42/21						
USFS*	Elk Ridge, Utah	PNN	20/10						
"	Elk Ridge, Utah	JUN	10/5						

PP-Ponderosa pine; PNN-Colorado pinyon pine; DF-Douglas fir; JUN-Juniper

*USFS-U. S. Forest Service

Table 2.--continued.

SPONSOR	SITE NAME	SPECIES	CORES/ TREE	EXAMINED	DATING CHECKED	CHRON. LENGTH	MEASURED	DATA PROCESSED	SELECTED CORES/TREES
USFS*	Devil's Canyon, Utah	PP	12/6						
MNA*	Cedar Mesa, Utah	PNN JUN	96 Sections						
ARPA	Bobcat Canyon, Colo.	DF	24/12	X	X	1388-1972			
"	Wetherill Mesa, Colo.	PNN	24/12	X	X	1611-1972			
"	Wetherill Mesa, Colo.	JUN	16/8	X	X	1817-1972			
"	Pueblito Canyon, N.M.	DF	29/14	X	X	1651-1972			
"	Pueblito Canyon, N.M.	PNN	25/12	X	X	1593-1972			
"	Ditch Canyon, N.M.	DF	28/14	X	X	1657-1972	X	X	22/11
"	Ditch Canyon, N.M.	PP	28/14	X	X	1554-1972	X	X	
"	Ditch Canyon, N.M.	PNN	24/12	X	X	1574-1972	X	X	
"	Ditch Canyon, N.M.	JUN	12/6	X	X	1692-1972			
TRL*	Aztec, N.M.	DF	12/6	X	X	1542-1970	X	X	12/6
"	Aztec, N.M.	JUN	12/6	X	X	1417-1970	X	X	12/6

PP-Ponderosa pine; PNN-Colorado pinyon pine; DF-Douglas fir; JUN-Juniper

*USFS-U. S. Forest Service; MNA-Museum of Northern Arizona; TRL-Tree-Ring Laboratory

Table 3.--Progress of Task 3. Collections in northeast, midwest and southeastern United States

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	DATING CHECKED	CHRON. LENGTH	MEASURED	DATA PROCESSED	SELECTED CORES/TREES
ARPA	Nancy Brook, N.H.	RS	36/18	X	X	1561-1972	X		
"	Livingston, Mass.	RS	31/15	X		1696-1972			
"	Other New England Sites	RS EWP HM	26/20	X	(too few from each site to be used)				
"	Seagull Lake, Minn.	RP	58/30						
"	Saganaga Lake, Minn.	RP	117/63						
"	Itasca St. Park, Minn.	RP	53/27						
U. of Chicago Collection									
"	Alabama								
	Al-Ma	oak	23						
"	Arkansas								
	A-Bo	oak	26						
	A-Fr	pine	27						
	A-Ga	WO pine	46						
	A-In	oak	27						
	A-Jo	oak pine	39						
	A-Ma	oak	25						

RS-red spruce; EWP-eastern white pine; HM-hemlock; RP-red pine; WO-white oak;

Table 3.--continued.

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	DATING CHECKED	CHRON. LENGTH	MEASURED	DATA PROCESSED	SELECTED CORES/TREES
U. of Chicago Collection	Arkansas (con'd.)								
	A-Mo	pine	45						
	A-Ne	WO	49						
	A-Pe	pine	45						
	A-Pp	WO SLP	61						
	A-Po	pine oak	44						
	A-Sa	pine	45						
	A-St	pine oak	50						
	Other Arkansas Sites	WO pine	42						
"	Delaware D-Su	ERC	9						
"	Illinois								
	I-J	ERC	27						
	I-Ja	oak	65						
	I-Wm	oak	42						
	Other Illinois Sites	ERC oak poplar elm cypress	54						

WO-white oak; SLP-shortleaf pine; ERC-eastern red cedar

Table 3.--continued.

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	DATING CHECKED	CHRON. LENGTH	MEASURED	DATA PROCESSED	SELECTED CORES/TREES
U. of Chicago Collection									
"	Indiana Sites	oak poplar	17						
"	Kentucky								
	K-B	oak cypress	66						
	K-C	oak	28						
	K-Ca	oak	26						
	K-Ch	oak	24						
	K-G	oak	56						
	Other Kentucky Sites	ERC oak pine poplar ash	46						
"	Louisiana La-Ls	oak	35						
"	Missouri								
	Mo-Ct	WO	45						
	Mo-Je	ERC	103						
	Mo-S	oak pine	106						
	Mo-StF	ERC	o						
	Mo-W	ERC	22						

WO-white oak; ERC-eastern red cedar

Table 3.--continued.

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	DATING CHECKED	CHRON. LENGTH	MEASURED	DATA PROCESSED	SELECTED CORES/TREES
U. of Chicago Collection									
"	Oklahoma								
	O-Cm	ERC	32						
	O-Cn	ERC	59						
	O-Mr	cedar	22						
	Other Oklahoma Sites	ERC oak hickory	30						
"	Tennessee								
	T-Br	pine oak	114						
	T-McM	pine oak	43						
	T-W	ERC	58						
	T-Wa	oak	25						
	Norris Basin	ERC NWC	215	26		1543-1942			
	Other Tennessee Sites	ERC oak pine	118						
"	Virginia V-R	oak	11						

ERC-eastern red cedar; NWC-northern white cedar

Table 3.--continued.

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	DATING CHECKED	CHRON. LENGTH	MEASURED	DATA PROCESSED	SELECTED CORES/TREES
U. of Chicago Collection									
"	West Virginia Sites	oak	6						
"	Wisconsin Sites	TM HM NWC	65						

TM-Tamarack; HM-Hemlock; NWC-Northern white cedar

Table 4.--Progress of Task 4. Collections in the Colorado drainage region and Yellowstone National Park

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	DATING CHECKED	CHRON. LENGTH	MEASURED	DATA PROCESSED	SELECTED CORES/TREES
Lake Powell Project	Uinta Mtns. A, Utah	ES	20/10	X	X	1433-1971	X	X	
"	Uinta Mtns. B, Utah	DF	20/10	X	X	1730-1971	X	X	
"	Uinta Mtns. C, Utah	DF	18/9	X	X	1640-1971	X	X	
"	Uinta Mtns. D, Utah	PNN	16/8	X					
"	Uinta Mtns. (North)	ES	31/15	X	X	1603-1971			
"	Windriver Mtns., WYO.	DF	24/12	X	X	1567-1972	X		
"	Windriver Mtns. A	LBP	22/10	X	X	1676-1972	X		
"	Windriver Mtns. B	DF	39/18	X	X	1503-1972			
"	Windriver Mtns. C	LBP	28/13	X	X	1498-1972			
"	Delores, Colorado	DF	22/11	X	X	1793-1971			
"	LaSal Mtns., Utah	ES	22/11	X	X	1494-1972			
"	LaSal Mtns. A	PNN	22/11	X	X	1488-1972			
Yellow-stone Nat. Park	Dead Indian Hill, WYO.	DF	32/16	X	X	1547-1972			
"	Gardiner A, Montana	DF	12/6	X	X				
"	Gardiner B, Montana	LBP	10/5	X	X	1184-1972			
"	Gros Ventre, WYO.	DF	54/27	X	X	1431-1972			
"	Spanish Creek, Mont.	DF	38/19	X	X	1622-1972			

ES-Engelmann spruce; DF-Douglas fir; PNN Colorado pinyon pine; LBP-Limber pine

Table 4.--continued.

SPONSOR	SITE NAME	SPECIES	CORES/ TREES	EXAMINED	DATING CHECKED	CHRON. LENGTH	MEASURED	DATA PROCESSED	SELECTED CORES/TREES
Yellow-stone Nat. Park	Uhl Hill, Wyoming	LBP	16/8	X	X	1442-1972	X	X	
"	Pacific Creek, WYO.	LBP	16/8	X	X	1051-1972			

LBP-Limber pine

REFERENCES

Fritts, H. C., T. J. Blasing, B. P. Hayden and J. E. Kutzbach. 1972. Multivariate techniques for specifying tree-growth and climatic relationships and for reconstructing anomalies in paleoclimate. Journal of Applied Meteorology, 10(5): 845-864.

Hawley, F. M. 1941. Tree-ring analysis and dating in the Mississippi drainage. The University of Chicago Publications in Anthropology, Occasional Papers, No. 2.

McDonald, J. E. 1957. A note on the precision of estimation of missing precipitation data. Trans. Am. Geophys. Union, 38(5): 657-661.